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RADIATION PROTECTION FOR SAFE HANDLING
OF ²⁵²Cf SOURCES*

by

C. N. Wright

Savannah River Laboratory
E. I. du Pont de Nemours and Company
Aiken, South Carolina 29801

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RADIATION PROTECTION FOR SAFE HANDLING
OF ^{252}Cf SOURCES*

Californium-252 may be used extensively as a new source of neutrons in the next few years.⁽¹⁾ Because of the high emission rate [2.4×10^{12} neutrons/(sec)(gram)] from spontaneous fission,⁽²⁾ californium can be fabricated into useful sources that are physically small -- one of its major attractions. The first sources were fabricated at this laboratory in the configuration of radium therapy needles.⁽³⁾ Because the users of these sources may be radiologists and medical personnel unfamiliar with neutron hazards, some of the characteristics of ^{252}Cf sources should be reviewed from a health physics viewpoint.

The neutron and gamma ray dose-equivalent rates from a microgram of ^{252}Cf in air are shown in Fig. 1. These relations were extrapolated by the inverse-square relation from Stoddard's⁽²⁾ calculations of neutron and gamma ray dose rates at one meter and were verified by actual measurements with a polyethylene ball neutron dosimeter and ^7LiF thermoluminescent dosimeters over the distances shown. The dose rate due to one milligram of radium is also shown for comparison.

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The greater dose rate from californium may be puzzling to the radiologist who has been told that a microgram of californium is about equal to a milligram of radium for therapeutic use.⁽⁴⁾ The difference is due to the quality factor used for radiation protection purposes, which is 3.3 times greater than that used in the therapy calculations. Less than 10% of the dose-equivalent rate in air is due to gamma rays.

Formulas for predicting dose rates in air from ^{252}Cf sources are given in Table I.

TABLE I

Dose-Equivalent Rates in Air
from ^{252}Cf Therapy Needles

$$\text{Neutron (mrem/hr)} = \frac{23,700 M}{r^2}$$

$$\text{Gamma (mrad/hr)} = \frac{1420 M}{r^2}$$

$$\text{Total (mrem/hr)} = \frac{25,120 M}{r^2}$$

where: M = microgram equivalent content of the source

r = distance from source in centimeters

These relations should not be applied to needle sources at distances less than 10 cm, where the source should be treated as a line source, rather than a point source.

Not only are dose rates higher from ^{252}Cf than from therapeutically equivalent amounts of radium, but shielding and storage problems are also different. Fig. 2 shows that two inches of lead will reduce the dose rate from radium to approximately 7% of its unshielded value, but will only reduce the dose rate from ^{252}Cf to 80% of the unshielded value.

The most effective shields for neutrons are those which contain large amounts of hydrogen, such as water, polyethylene, and paraffin.

Dose rates from shielded ^{252}Cf sources must be measured with care. Since the average neutron energy of these sources (2.34 Mev) is considerably lower than that from PuBe or PoBe sources, a large percentage of the neutrons may be reduced in the shield to energies below the detection threshold of "fast neutron" survey meters. Hence, the estimated dose may be erroneously low. The Bonner Sphere type⁽⁵⁾ or the Rem Counter type⁽⁶⁾ survey instrument is probably the best method to establish exposure rates from ^{252}Cf sources because they respond to neutrons having energies from thermal to 7.0 Mev.

Savannah River Laboratory
E. I. du Pont de Nemours and Company
Aiken, South Carolina 29801

C. N. Wright

REFERENCES

1. W. C. Reinig, "Advantages and Applications of ^{252}Cf as a Neutron Source" to be published in Nuclear Applications.
2. D. H. Stoddard, Radiation Properties of Californium-252. USAEC Report DP-986, Savannah River Laboratory (1965).
3. C. N. Wright, A. R. Boulogne, W. C. Reinig, and A. G. Evans, Radiology **89** (2), (1967).
4. G. D. Oliver, Jr. and C. N. Wright, "Dosimetry of an Implantable ^{252}Cf Source." To be published.
5. D. E. Hankins, A Neutron Monitoring Instrument Having a Response Approximately Proportional to the Dose Rate from Thermal to 7.0 MeV. USAEC Report LA-2717, Los Alamos Scientific Laboratory (1962).
6. I. O. Anderson and J. Braun, A Neutron Rem Counter, AE-132, Aktiebolaget Atomenergi, Stockholm, (1964).

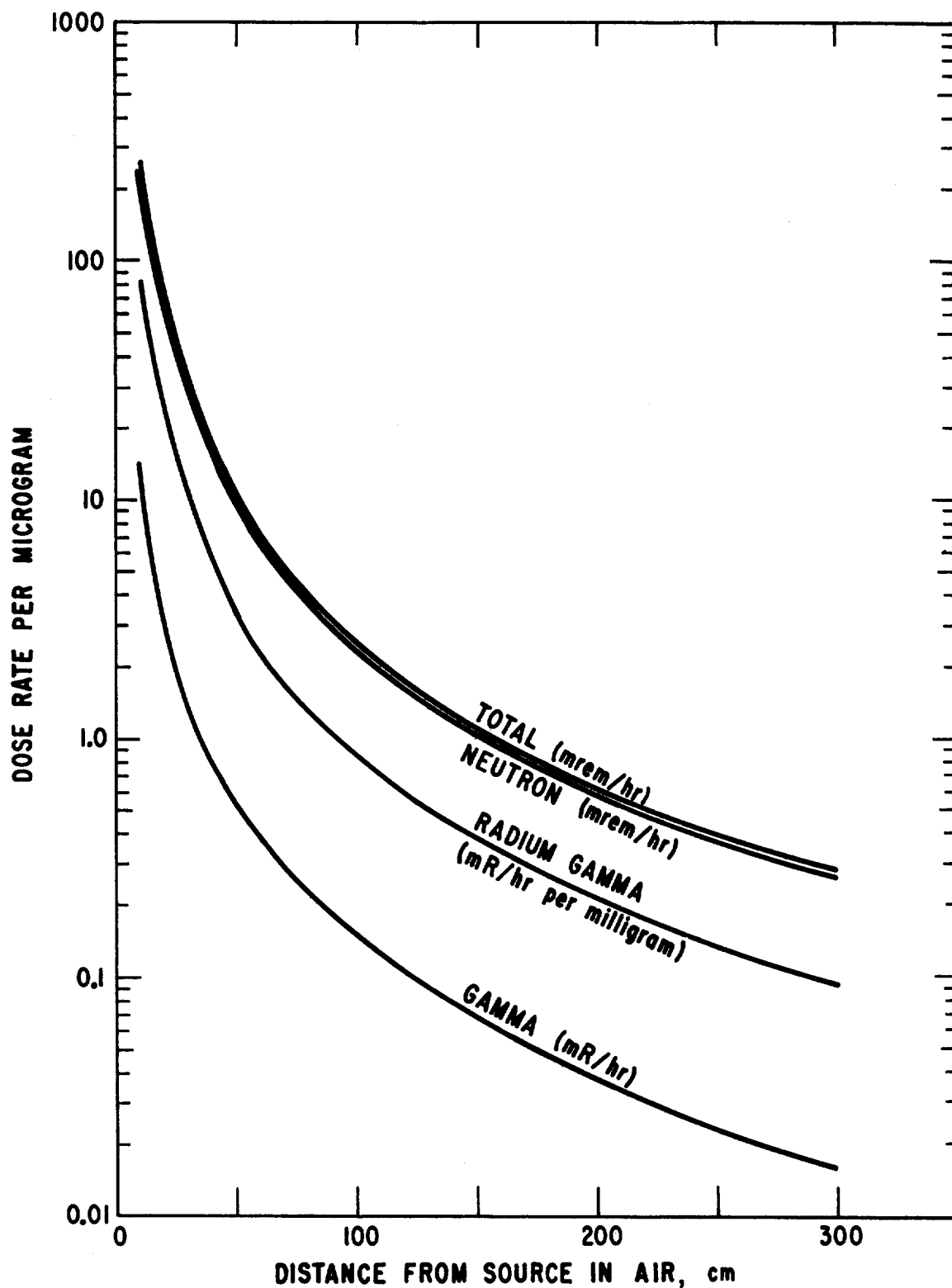


FIG. 1 DOSE EQUIVALENT RATES FROM ^{252}Cf SOURCES IN AIR

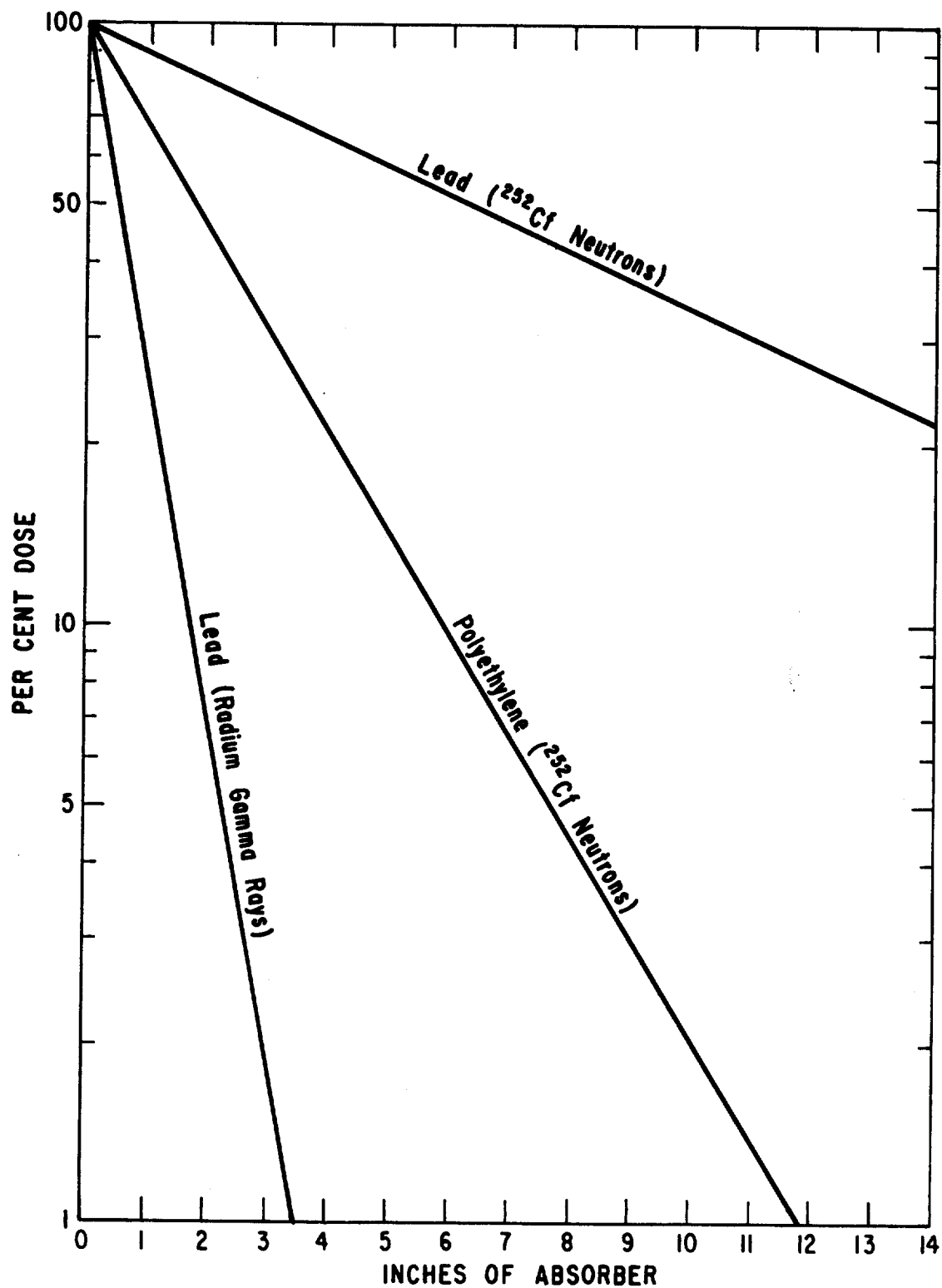


FIG. 2 SHIELD ATTENUATION CHARACTERISTICS